Apr 11th, 11:00 AM - 12:00 PM

Air and Soil Temperature Variability in Northern Alaska

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Comparison of Instrumentation to Measure Air and Soil Temperatures in Northern Alaska

INTRODUCTION

The Circumpolar Active Layer Monitoring (CALM) Project has been monitoring permafrost (perennially frozen ground) and its overlaying active layer (which freezes and thaws annually) throughout northern Alaska's Kuparuk River watershed and various polar regions since the mid 1990's to detect long-term responses to our changing climate. The soil-surface temperature data is collected by thermistors that were positioned immediately below the surface of the ground at nine locations within a transect of 1-ha plots arranged from north to south across the region. Locations within each plot were individually selected to represent a full range of microsite conditions, with distinctions in vegetation, moisture, and microtopography. Three different datalogger models from Onset Computer Corporation® were deployed in pairs over 1-year durations from 2005-2006 and 2011-2012. Analyzing the systematic variations due to vegetation, air temperature, and moisture is necessary to quantify the reliability and consistency of the Flux Study Site dataset.

STUDY AREA

Alaska's Kuparuk River flows northward from the Brooks Range. The Kuparuk River watershed spans several distinct bioclimatic zones with soil/vegetation associations ranging from moist acidic to non-acidic tundra. The Flux Study sites were chosen to represent a range of soil-surface conditions from many micro-topographic sites.

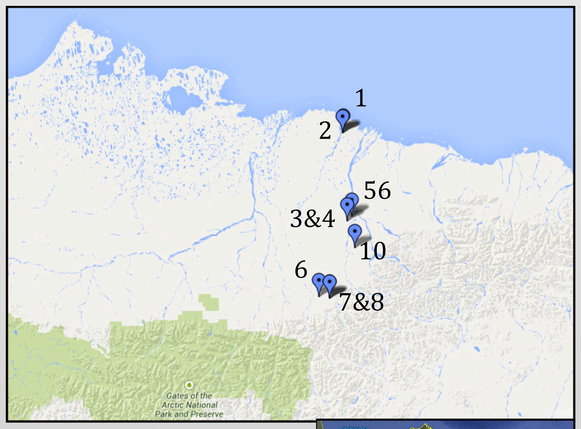

Figure 1: Above: Alaska's North Slope marked with Flux Study sites 1-10 between the Brooks Mountain Range and the Beaufort Sea. Site 5 was largely deactivated, Site 9 washed away, and a site was added at mile "56" on the highway at the southern-most margin of the coastal plain just north of the foothills physiographic province. Flux Sites 3 and 4 are in the foothills. Right: Overview map of Alaska with the Flux Study sites marked.

METHODOLOGY

At each 1-ha plot, a series of dataloggers manufactured by Onset Computer Corporation® were installed which measure and record 9 soil-surface and one air temperature. The thermistors were installed immediately below the surface of the ground at each site, which were each selected to represent the full range of microsite conditions within each plot. Data are recorded at 2-hour intervals and stored for download each August. In 2005 and 2011 the team replaced older instrumentation with newer models which ran side-by-side for 1 year. Comparing the temperatures records from these different instrumentation models (Stowaway, Hobo Pro, and V2, from oldest to newest) allows us to quantify the variability within the dataset.

RESULTS

Statistical comparisons between the 2005-2006 Stowaway/Hobo Pro and the 2011-2012 Hobo Pro/V2 bi-hourly temperature differences yielded several results:

- Mean differences over the period of record were low (<±0.5°C).
- Temporal variability in the differences are systematically related to seasonal cycles, with the largest differences in summer when the active layer thaws and is the most dynamic.
- Spatial variability within and between the plots is revealed by systematic differences in micro-site locations with larger differences at warmer, drier sites (e.g. Figure 8 showing Flux site 3 datalogger unit 3).

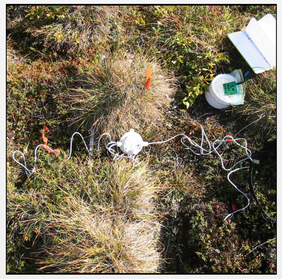

Figure 2: Flux site 8, logger 7. Located at Imnavait Creek, a moist acidic site with watertracks. Unit 7 is a muddy inter-tussock microsite.

Figure 3: Flux site 1, logger 8. Located at Sagwon, a moist non-acidic tundra site. Unit 8 is a very wet microsite in an ice-wedge trough.

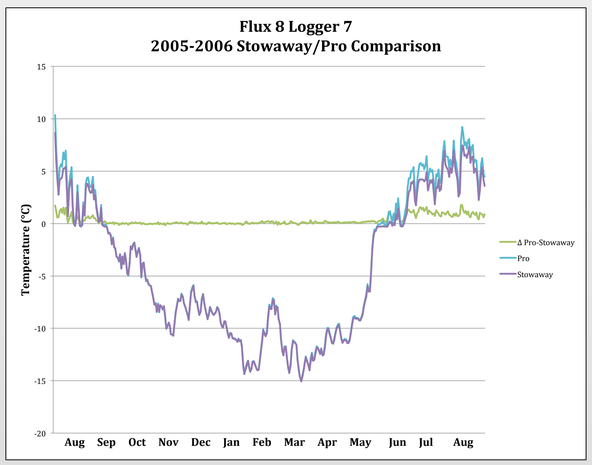

Figure 5: Flux 8, logger 7. Plot showing the temperatures from the Stowaway, Hobo Pro, and the difference between them recorded at the microsite shown in Figure 2. The annual mean difference was 0.32°C.

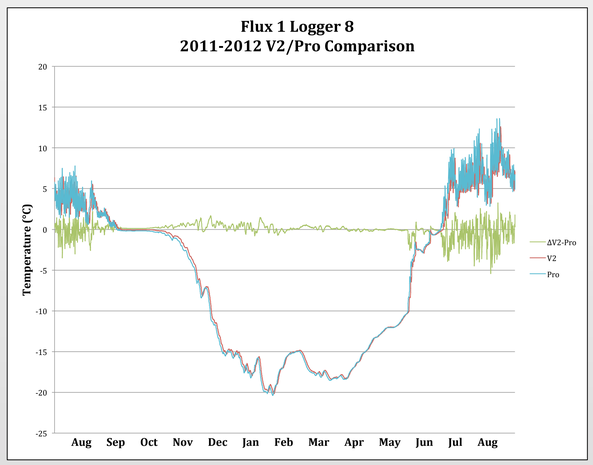

Figure 6: Flux 1, Logger 8. Plot showing the temperatures from the V2, Hobo Pro, and the difference between them recorded at the microsite shown in Figure 3. The annual mean difference was 0.02°C.

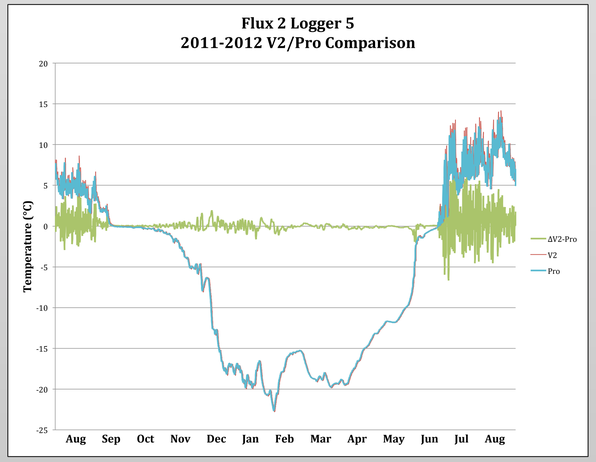

Figure 7: Flux 2, logger 5. Plot showing the temperatures from the V2, Hobo Pro, and the difference between them recorded at the microsite shown in Figure 9. The annual mean difference was 0.06°C.

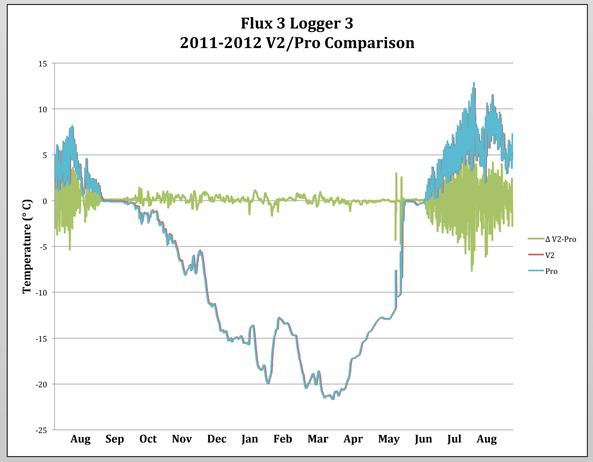

Figure 8: Flux 3, logger 3. Plot showing the temperatures from the V2, Hobo Pro, and the difference between them recorded at the microsite shown in Figure 10. The annual mean difference was 0.03°C.

Figure 9: Flux site 2, logger 5. Located at Betty Pingo, a wet site on the coastal plain by Prudhoe Bay. The site is flat with low-centered polygons and wet, non-acidic tundra. Unit 5 is within a low-centered polygon microsite.

Figure 10: Flux site 3, logger 3. Located at Sagwon, a moist non-acidic site in the northern foothills. The site has northwest-facing slope of 4° with non-sorted circles. Unit 3 is a dry, high microsite on the edge of a tussock.

Summary statistics (Figures 11 & 12) from the year-long comparison of 2005-2006 Hobo Pro/Stowaway (Figure 5) and the 2011-2012 V2/Hobo Pro (in Figures 6-8) bi-hourly temperature differences show the consistency of the different instrumentation.

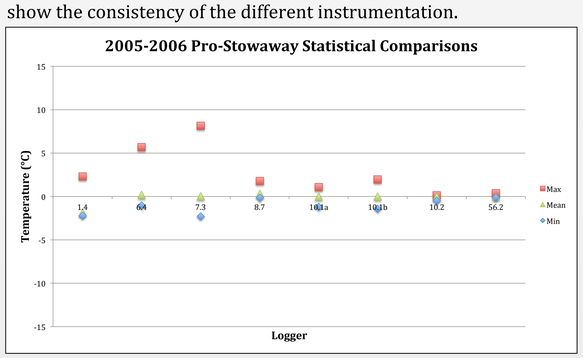

Figure 11: The Hobo Pro/Stowaway comparison summary statistics of maximum, minimum, and mean differences in bi-hourly temperatures from the available study sites (n=10), which are labelled as "Flux Study site . logger number", for instance Flux site 7, logger 5 is shown as "7.5".

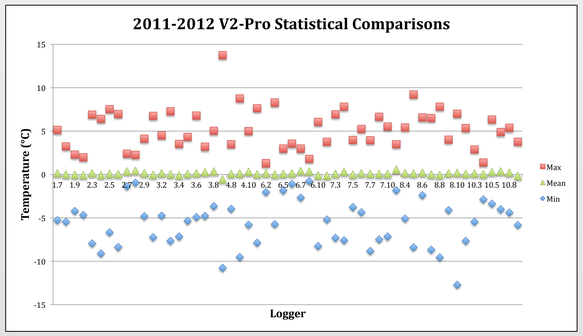

Figure 12: The V2 /Pro comparison summary statistics of maximum, minimum, and mean differences in bi-hourly temperatures from the available study sites (n=##), which are labelled as "Flux Study site . logger number".

CONCLUSIONS

This analysis helped quantify the reliability of a 18-year air and soil-surface temperature dataset in northern Alaska. These plots were established to monitor the active layer of permafrost, as the thickening of this layer may lead to a positive feedback of greenhouse gases into the atmosphere. These data have been used to study climatic change within the region (Streletskiy et al., 2008), ecosystem-level responses (Nyland et al., 2012), improve modeling efforts (Klene et al., 2001a, 2001b, 2008), and predict soil subsidence (a hazard for human infrastructure such as roads, pipelines, and nuclear power plants (USARC)).

ACKNOWLEDGEMENTS

We appreciate the 2014 Undergraduate Research Award the University of Montana's Davidson Honors College awarded to KK for this research. Funding was provided by U.S. National Science Foundation (NSF) grants OPP-9529783, OPP0352958, and OPP-0856421. We thank British Petroleum for granting access to sites located within the Prudhoe Bay oil field. Any opinions, findings, conclusions, or recommendations expressed in the material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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